Analyzing the CIFAR-10 Data set

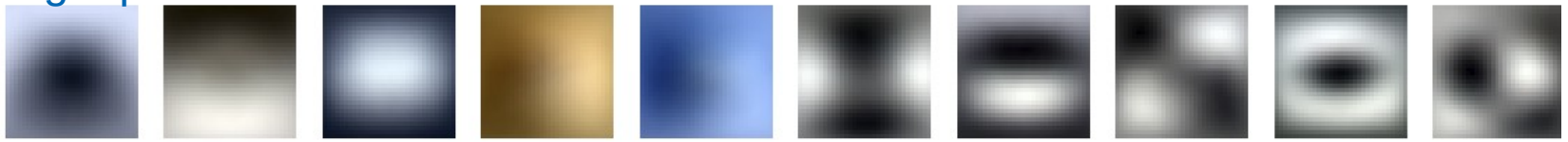
Practical Lab Numerical Simulation

- CIFAR-10 data set:
  - 60,000 images of size 32 x 32
  - Labeled as one of 10 objects

- Implement PCA
- Implement Convolution Neural Networks
- Evaluation and comparison of results
- Examples of network mistakes

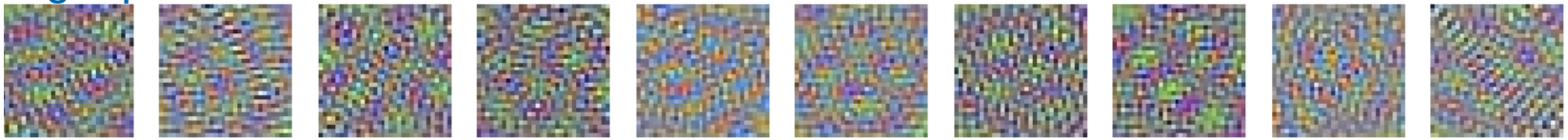
Principal Component Analysis

Eigenpictures 0-9



Eigenpictures 50-59

Eigenpictures 600-609



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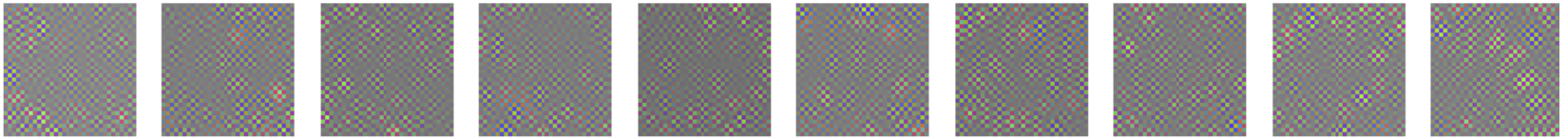
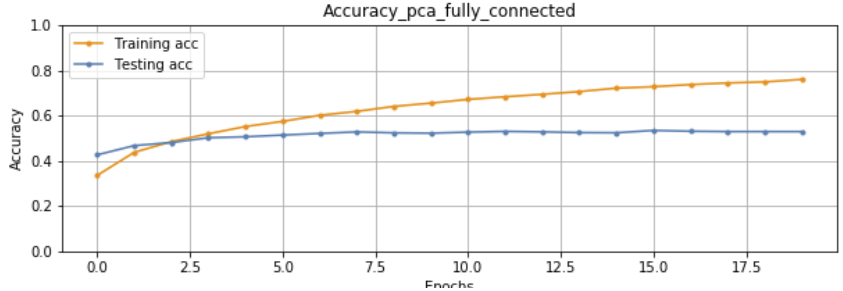
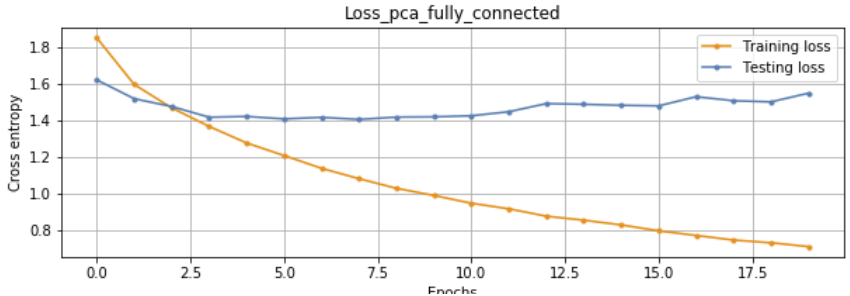
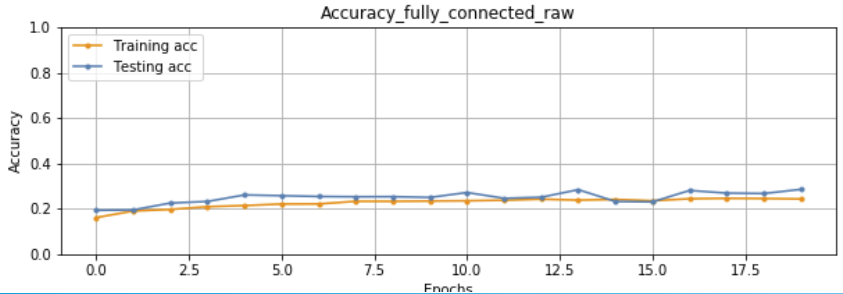


Principal Component Analysis







Layer (type)	Output Shape	Param #
dense_19 (Dense)	(None, 512)	307712
dropout_16 (Dropout)	(None, 512)	0
dense_20 (Dense)	(None, 512)	262656
dropout_17 (Dropout)	(None, 512)	0
dense_21 (Dense)	(None, 256)	131328
dropout_18 (Dropout)	(None, 256)	0
dense_22 (Dense)	(None, 256)	65792
dropout_19 (Dropout)	(None, 256)	0
dense_23 (Dense)	(None, 128)	32896
dropout_20 (Dropout)	(None, 128)	0
dense_24 (Dense)	(None, 10)	1290

Convolution Neural Network

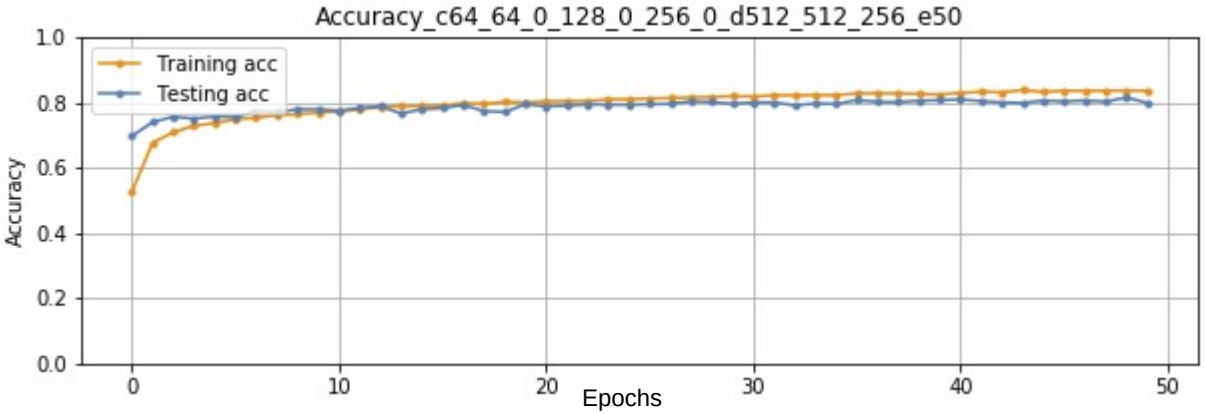
- Used for image classification
- Important parameters: Normalized data, Batch size, epochs, SGD/Adam optimizer, regularization, initialization, activation function
- Keras documentation and examples

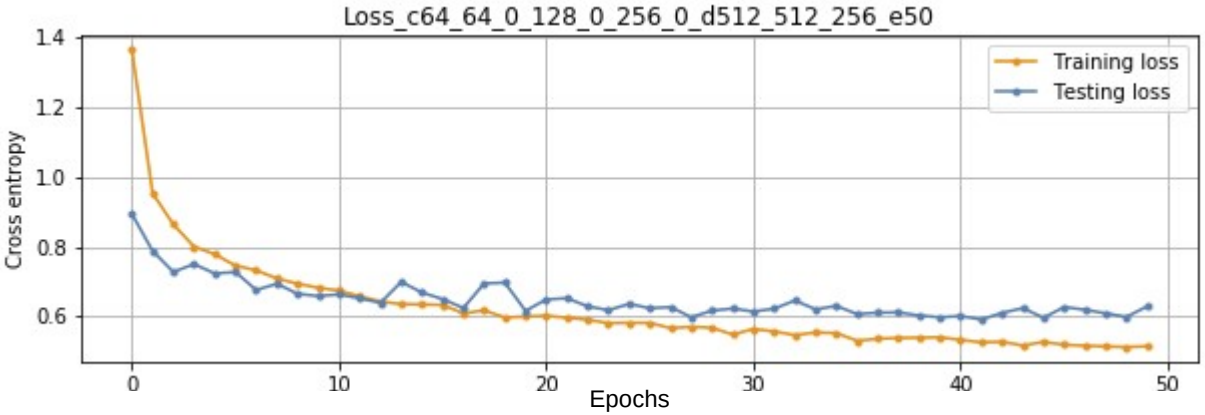
Analysis of Model

- After 50 epochs – 79% accuracy
- Similar error rate to initial papers[1,2]
- Much less than 99% achieved in Nov, 2018[3]
- Similar to Keras examples
- Makes expected mistakes
- Good at differentiating certain objects

[1] 78.9% accuracy Convolution Deep Belief Networks on CIFAR-10. Alex Krizhevsky
[2] 65% accuracy Learning Multiple Layers of Features from Tiny Images. Alex Krizhevsky
[3]Huang, Yanping; Cheng, Yonglong; Chen, Dehao; Lee, HyoukJoong; Ngiam, Jiquan; Le, Quoc V.; Zhifeng, Zhifeng (2018-11-16). "GPipe: Efficient Training of Giant Neural Networks using Pipeline Parallelism. ArXiv: 1811.06965

Model Structure and History





Layer (type)	Output Shape	Param #
conv2d_1 (Conv2D)	(None, 64, 32, 32)	1792
conv2d_2 (Conv2D)	(None, 64, 32, 32)	36928
max_pooling2d_1 (MaxPooling2	(None, 64, 16, 16)	0
dropout_26 (Dropout)	(None, 64, 16, 16)	0
conv2d_3 (Conv2D)	(None, 128, 16, 16)	73856
max_pooling2d_2 (MaxPooling2	(None, 128, 8, 8)	0
dropout_27 (Dropout)	(None, 128, 8, 8)	0
conv2d_4 (Conv2D)	(None, 256, 8, 8)	295168
max_pooling2d_3 (MaxPooling2	(None, 256, 4, 4)	0
dropout_28 (Dropout)	(None, 256, 4, 4)	0
flatten_1 (Flatten)	(None, 4096)	0
dense_31 (Dense)	(None, 512)	2097664
dropout_29 (Dropout)	(None, 512)	0
dense_32 (Dense)	(None, 512)	262656
dropout_30 (Dropout)	(None, 512)	0
dense_33 (Dense)	(None, 256)	131328
dropout_31 (Dropout)	(None, 256)	0
dense_34 (Dense)	(None, 10)	2570

Results – Confusion Matrix

Label/ Prediction	Airplane	Automobile	Bird	Cat	Deer	Dog	Frog	Horse	Ship	Truck
Airplane	831	8	**56**	17	8	11	5	13	29	9
Automobile	5	896	1	3	0	0	0	0	13	46
Bird	21	3	664	48	45	42	16	23	4	4
Cat	14	5	34	**574**	21	**111**	30	44	9	18
Deer	21	3	77	80	821	51	16	**98**	9	3
Dog	3	3	47	**161**	13	732	8	105	2	3
Frog	17	9	99	98	79	36	**920**	9	12	11
Horse	6	1	6	4	6	9	0	703	0	6
Ship	58	22	15	7	6	5	4	2	907	31
Truck	**24**	**50**	1	8	1	3	1	3	**15**	869

Worst Mistakes

Label: Car, P: Truck

Label:Ship, P: Frog

Label: Truck, P: Car

Label: Cat, P: Frog

Label: Truck, P:Ship

Label: Car, P: Truck

Label: Car, P: Ship

Label: Car, P: Truck

Label: Deer, P: Frog

Label: Deer, P: Frog